ADITYA UNIVERSITY

Department of Physics

Ph.D Course Work

(Applicable for the scholars admitted from the AY:2024-25)

The credit requirement for the Ph.D. course work is a minimum of 12 credits including the courses on 'Research Methodology' and 'Research and Publication Ethics' for 2 credits each. The candidate must complete two domain-specific courses of 3 credits each, recommended by the respective Department Research Committee (DRC). These courses can be completed through MOOCs.

The candidate must present two research seminars before the completion of course work, typically within the first year. The first research seminar shall be before the end of first semester on introduction to the proposed research work, and the second seminar shall be before the end of the second semester or after the completion of course work on the research proposal, as per the format provided. Each research seminar will have one credit weightage. The course structure is presented in Table 1 and list of domain-specific courses is presented in Table 2.

Table 1: Course Structure

S.No.	Course Code	Name of the Course	Credit(s)
1	246UC001	Research Seminar-I	1
2	246UC002	Research Seminar-II	1
3	246UC003	Research Methodology	2
4	246UC004	Research and Publication Ethics	2
5		Domain Specific Course-I	3
6		Domain Specific Course-II	3
Total			**12**

Table2: List of Domain-Specific Courses

S.No.	Course Code	Name of the Course
1	246PH001	Quantum Mechanics
2	246PH002	Materials Science
3	246PH003	Polymers and Nano-Composites
4	246PH004	Nano-Magnetism
5	246PH005	Introduction to Low Temperature Liquids and Amorphous Materials
6	246PH006	Modern Physics
7	246PH007	Glass Science
8	246PH008	Industrial Nanotechnology
9	246PH009	Surface Engineering for Nanotechnology
10	246PH010	Advanced Equilibrium and Non-Equilibrium Statistical Mechanics
11	246PH011	Fundamentals of Spectroscopy
12	246PH012	Atomic And Molecular Physics
13	246PH013	Elements of Modern Physics
14	246PH014	Electronic Theory of Solids
15	246PH015	Characterization of Polymers Elastomers and Composites
16	246PH016	Properties of Glass Materials

Research Methodology

Course Code: 246UC003

UNIT -I:
Research Design
Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Case studies.

UNIT-II:
Data Collection and Sources
Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT-III:
Data Analysis and Reporting
Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT-IV:
Intellectual Property Rights
Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT-V: Patents
Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

Text Books:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Sage Publications, 4th Edition, 2015.
2. Intellectual Property: A Very Short Introduction, Siva Vaidhyanathan, Oxford University Press, 2017.
3. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" Deborah E. Bouchoux, Cengage India, 4th Edition, 2013.

Reference Books:

1. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard, Juta Academic, 2nd Edition, 2014.
2. Research design: Qualitative, quantitative, and mixed methods approaches, Creswell, J.W. and Creswell, J.D., Sage publications, 2017.
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, Clause 8 Publishing; Volume I: Perspectives, Trade Secrets & Patents; 2023.

Web Links:
1. https://archive.nptel.ac.in/courses/121/106/121106007/#
2. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview

Research and Publication Ethics

Course Code: 246UC004

Unit-I: Philosophy & Ethics
Introduction to Philosophy: Definition, Nature & Scope, Concept, Branches
Ethics: Definition, Moral Philosophy, Nature of Moral Judgements & Reactions

Unit-II: Scientific Conducts
Ethics with respect to Science and Research, Intellectual Honesty & Research Integrity
Scientific Misconducts: Falsification, Fabrication & Plagiarism
Redundant Publications: Duplicate & Overlapping Publication, Salami Slicing, Selective Reporting & Misrepresentation of Data

Unit-III: Publication Ethics
Publication Ethics: Definition, Introduction and Importance
Best Practices/ Standard Setting Initiatives and Guidelines: COPE, WAVE, etc., Conflicts of Interest
Publication Misconduct: Definition, Concept, Problems that lead to unethical behaviour and vice-versa, types, Violation of Publication Ethics, Authorship and Contributorship, Identification of Publication Misconduct, Complaints and Appeals, Predatory Publishers and Journals

Unit-IV:Open Access Publishing
Open Access publications and Initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-achieving policies, Software tool to identify predatory publications developed by SPPU, Journal Finder/ Journal Suggestion tools viz. JANE, ELSEVIER, SPINGER, Journal suggester etc.

Unit-V: Publication Misconduct
Group Discussions:
Subject-specific Ethical issues, FFP, Authorship, Conflicts of Interest, Complaints and Appeals: Examples and fraud from India and Abroad
Software tools:
Use of Plagiarism software like Turnitin, Urkund and other open source software tools
Database and Research Metrics:
Database:
Indexing database, Citation database: web of science, Scopus etc.
Impact factor of journal as per journal citation report, SNIP, SJR, IPP, cite score
Metrics: h-index, g-index, i-10 index, AL metrics etc.

Text Books:
1. Philosophy in Science, Bird A, Routledge, 2006.
2. A Short History of Ethics, MacIntyre, London, 1967.

Reference Book:
1. Ethics in Science, Education and Governance, Indian National Science Academy, 2019.

Weblinks:

1. www.niehs.nih.gov/research/resources/bioethics/whatis
2. https://onlinecourses.swayam2.ac.in/nou22_ge73/preview

Quantum Mechanics

Course Code: 246PH001

UNIT– I:
Origin of Quantum Theory, Revision; Inadequacy of classical mechanics; Schrodinger equation, postulates of quantum mechanics, continuity equation; Ehrenfest theorem; Admissible wave functions; Stationary states. One-dimensional problems, wells and barriers; problem of Harmonic oscillator by Schrodinger equation.

UNIT– II:
Uncertainty relation of x and p, states with minimum uncertainty product; operators – use of operators in quantum mechanics, Bracket notation, orthonormal functions, linear operators, Hermitian operator and properties, equation of motion of an operator –Schrodinger representation, Dirac delta function- properties, the continuous spectrum.

UNIT– III:
Angular momentum in QM; particle moving in a spherically symmetric potential, spherical harmonics, radial equation, Eigen values and Eigen functions of rigid rotator, Hydrogen atom, angular momentum operator, Commutation relations.

UNIT– IV:
Time-independent perturbation theory; Non-degenerate systems –application to ground state of helium atom and degenerate systems- Stark effect. Vibrational method: WKB approximation.

UNIT–V:
Development of time dependent perturbation theory; the golden rule for constant transition states, Klein-Gordon equation- its success and limitations, Dirac equation for a free particles, Equation of continuity, spin of Dirac particle, negative energy states.

Text Books:

1. Schiff,L.I.,1968.*QuantumMechanics*.McGraw-Hill.
2. Crossman,B.andPowell,J.D.,1955.*QuantumMechanics*.AddisonWesley.

Reference Books:

1. Mathews,P.M.andVenkatesan,K.,1976.*QuantumMechanics*.TataMcGraw-Hill.
2. Rajput,B.S.,1995.*AdvancedQuantumMechanics*.Pragati Prakashan.

Materials Science

Course Code: 246PH002

UNIT-I:
Dielectrics
Dielectric polarization and atomic forces-electronic polarization, mechanism of polarization, macroscopic description of the static dielectric constant of materials, the electronic and ionic polarizabilities of molecules. Orientational Polarization, Measurement of dielectric constant of a solid, dielectric breakdown-electric energy stored in dielectrics, the internal field of Lorentz, Clausius-Mosotti relation, dielectric losses and relaxation times, elementary ideas on dipole relaxation.

UNIT-II:
Ferroelectrics
Ferroelectrics: General characteristics – piezoelectric, pyroelectric and ferroelectric materials. Classification of ferroelectric crystals and representative materials– $BaTiO_3$ and its ferroelectric behavior, structure of KDP and explanation for its ferroelectric behavior, spontaneous polarization and theory of spontaneous polarization in $BaTiO_3$, Dielectric theory of ferroelectricity, ferroelectric hysteresis.

UNIT-III:
Magnetic Properties
Quantum theory of diamagnetism, Origin of permanent magnetic moment, Theories of paramagnetism, paramagnetic cooling, spontaneous magnetization, Weiss theory of spontaneous magnetization, Nature and origin of the Weiss molecular field, Heisenberg exchange interaction, Hysteresis. The Block wall, Neel's theory of Antiferromagnetism. Ferromagnetism, Ferrite's and their applications (basic concepts only).

UNIT-IV:
Superconductivity
Superconductors, Occurrence of superconductivity, properties of super conductors, Experimental observations, persistent currents, Effect of magnetic fields, Meissner effect, Type I and Type II super conductors, Elements of BCS theory, Cooper pairs, AC and DC Josephson effects, Superconducting Quantum Interference Devices (SQUID), High temperature superconductors, applications of superconductors.

UNIT-V:
Optical Properties
Feynman's vision, nanotechnology and nano-science, history of nano-materials, concept of nanoparticle, size dependent properties, length scales, classification of nano-materials, zero, one, two and three dimensional nanostructures, quantum dots, nano-wires, ultra-thin films. LED materials, liquid crystals, properties and structure, liquid crystal displays, comparison between LED and LC displays.

Text Books:

1. Sekhar,M.C. and Naidu,P.A.,2013. Applied Physics. Spectrum University Press.
2. Arumugam,M.,2002.MaterialScience.AnuradhaPublishers.
3. Callister, W.D., 2007. Materials Science and Engineering: An Introduction. 7th ed. John Wiley & Sons.

Reference Books:

1. Phillips,J.C. 1989.Physicsof High Tc Superconductors. Boston: Academic Press.
2. GoddardIII,W.A.,etal.(Eds.) 2007.HandbookofNanoscience,Engineering,andTechnology. Taylor & Francis Group.
3. Cao,G.2004.Nanostructures and Nanomaterials:Synthesis, Properties, and Applications. London: Imperial College Press.

Polymers and Nano-composites

Course Code: 246PH003

UNIT-I:

BasicAspectsClassification-Somebasicdefinitions-Additionandcondensationpolymerizations, and copolymerization - Mechanism of free radical, cationic and anionic polymerizations. Polymerization Techniques: Bulk, Solution, Suspension and Emulsion polymerizations - Polymerization using metal catalysts and surfactants.

UNIT-II:

Molecular weight of polymers Number average, weight average and viscosity average molecular weights of polymers - Determination of molecular weight of polymers by GPC and viscometry methods. Bio-polymers, Bio-degradable polymers, Fire retardant / Thermally stable polymers, Polymer electrolytes, Liquid armor polymers and Liquid crystalline polymers.

UNIT-III:

ConductingPolymersDiscovery–Structuralcharacteristicsanddopingconcept -Charge carriers and conducting mechanism – Classification of conducting polymers: Intrinsic and extrinsic conducting polymers - Chemical and electrochemical methods of the synthesis of conducting polymers – Applications of conducting polymers in corrosion protection, sensors, electronic and electrochemical energy devices.

UNIT-IV:

Polymer Nano composites Definition of nano-composites – Nano fillers, Classification of nano- fillers, Synthesis and properties of nano-fillers - Types of nanocomposites – Synthesis of nano composites: Direct mixing, solution mixing, In-situ polymerization-Polymer/Metal oxide nano- composites, diblock copolymer based nano composites, Polymer/CNTs and Polymer/Nano clay based composites and their properties and functional applications.

UNIT-V:

Novel Nano composites Fractal based Glass – metal nano composites - Core-shell structured nano- composites - Super hard nano-composites - Self-cleaning nano-composites - Metal matrix nano- composites: Metal with nano-ceramic fillers such as SiC, CeO2, TiO2, ZrO2 PTFE, CNTs and their mechanical, corrosion resistance properties and functional applications.

Text Books:

1. Ruiden,A.,1998.Elementsof Polymer Science and Engineering. Elsevier Science.
2. Meyer,B.,1994. AText Book of Polymer Chemistry. JohnWiley &Sons, Singapore.
3. Gowariker,V.R.and Viswanathan,N.V., 1986.PolymerScience.WileyEastern.

Reference Books

1. Odian,G., 1933.Principles of Polymerization.John Wiley& Sons.
2. Wan,M.,2008.ConductingPolymerswithMicroorNanoMeterStructure.Springer.

Nano-Magnetism

Course Code: 246PH004

UNIT-I:
Origin of Magnetism
Basics of magnetic materials, magnetic flux, magnetization, magnetic induction, susceptibility and permeability, diamagnetism and diamagnetic susceptibility, Paramagnetism, Curie law and Curie- Weiss law, Pauli paramagnetism, Ferromagnetism, hysteresis, magnons, domain theory, ferrimagnetism, antiferromagnetism

UNIT-II:
Giant Magneto Resistance
Introduction to spintronics, magneto resistance in normal metals, MR ratios, Giant magneto resistance in ferromagnetic multi layers and super lattices, co-operative phenomena and magnetization reversal, applications in spin valve and read heads, comparison of GMR and AMR, oscillation of coupling energy, non-coupling type GMR, CPP and CIPGMR, GMR in nano grains, mechanism of GMR.

UNIT-III:
Tunnel Magneto Resistance
Introduction to tunnel magneto resistance, ferromagnetic tunnel junctions, experiments for TMR, phenomenological theory of TMR, MR ratio and spin polarization, factors influencing TMR, MR ratio for Fe/MgO/ Fe system, oscillations in TMR, tunnel junctions with manganites, Heusler alloys, nano scale graunules, Coulomb blockade in tunnel junctions.

UNIT-IV:
Magnetic Nano-Structures
Magnetism of nanoparticles, nano clusters, nano wires, hard and soft magnetic materials and their applications, media for extremely high-density recording, magnetic sensors, ferro fluids, spin glass-magnetic properties and electronic structure

UNIT-V:
Nano-Biomagnetism
Magnetic targeting, magnetic separation and detection, magnetic tweezers, drug and gene delivery, chemotherapy, MRI, magnetic contrast agents, hyperthermia, application of various nano magnetic materials in biotechnology, superparamagnetism, core- shell structures and their applications, iron oxide and novel Nanomaterials.

Text Books:
1. Sellmyer,D.and Skomski,R.(eds.),2009.*Advanced Magnetic Nanostructures*. Springer.
2. Reed,M.A.(ed.),2002. *Magnetic Nanostructures*. American Scientific Publishers.

Reference Books:
1. Mohn,P.,2003.Magnetisminthe Solid State. Springer Series in the Solid State Sciences. Springer
2. Nalwa,H.S.(ed.),2002.Handbook of Thin Film Materials.Vol.5.American Scientific Publishers.

3. Nalwa,H.S.(ed.),2007.Encyclopaedia of Nano-science and Nanotechnology. American Scientific Publishers.

Introduction to Low Temperature Liquids and Amorphous Materials

Course Code: 246PH005

Unit- I:
Introduction to Liquid Matter
Fluid state, Intermolecular interaction, Van der Waals attraction, Hard sphere repulsion, Equilibrium structure of the liquid, Local order and pair structure, Time correlation functions, Linear transport coefficients

Unit- II:
Super cooled liquids
Temperature Dependence of liquids, strongly correlated liquid, Arrhenius dependence, Diffusion coefficient, Stokes-Einstein relation, metastable equilibrium, Response function, Fluctuation-dissipation theorem

Unit -III:
Relaxation Dynamics of Supercooled Liquids
Time dependent correlation, Cooperative motion, Ergodic-nonergodic transition, Free-energy landscape, Non-exponential relaxation, higher order correlation function, Dynamical heterogeneity

Unit -IV:
The Glass-transition and Amorphous solids
Glassy systems, Experimental signatures, Entropy crisis, Mode-Coupling theory, Free volume Theory, Random first order theory, Polydispersity, Structure of amorphous materials, Structure factor

Unit -V:
Mechanical Properties of Amorphous solids
Models of crystalline plasticity, Elastoplastic theory, Stress-strain curve, Young modulus, Simple and Pure shear, Quasistatic limit, Finite strain rate, Stress drops and avalanches, Yielding Transition, Strain localization, Shear-banding

Text Books:

1. Binder,K.andKob,W.,2011.GlassyMaterialsandDisorderedSolids.WorldScientificPublishing Co. Pte. Ltd.
2. Barrat,J.-L.andHansen,J.-P.,2003.BasicConceptsforSimpleandComplexLiquids. Cambridge University Press, UK.

Reference Books:

1. Takasuke Matsuo,1998.Low temperature thermal properties of amorphous materials. International Union of Pure and Applied Chemistry.

Modern Physics

Course Code: 246PH006

Unit–I:
Electromagnetic Waves
Equation of continuity, Maxwell's equations, Maxwell's equations in integral and differential forms, Physical Significance, Pointing theorem, Poynting vector, The wave equation, plane Electromagnetic wave in free space, plane Electromagnetic wave in anisotropic non conducting medium, plane Electromagnetic wave in isotropic non conducting medium, plane Electromagnetic wave in conducting medium.

Unit–II:
Defects in Solids
Introduction, classification of imperfections, point defects; vacancies, impurities, interstitials, color cantus, Schott key defects, Frenkel defects. Estimation of concentration of Schott key defects and Frenkel defects at a given temperature. Line Defects: Edge dislocation, Screw dislocation, Burger's circuit and Burger's vector.

Unit–III:
Super conductors
Superconducting phenomenon, Zero electrical resistance, Meissner's effects, magnetic phase diagram, energy gap, isotope effect, flux quantization, Josephson effect and tunneling, SOULD, London equations, BCS theory, application of superconductors.

Unit–IV:
Photonic devices
Light emitting diodes, photo diode, solar cells, photo transistor.

Text Books:
1. Jordan,E.C.andBalmain,K.G.,1968.EMWavesandRadiatingSystems.2nded. Prentice Hall.
2. Prasad,S.,2011.ElectromagneticTheoryandElectrodynamics.SciTechPublications.

Reference Books:
1. Kittel,C., 2005.Introduction to Solid State Physics. 8thed. John Wiley& Sons.
2. Sze,S.M., 2006.Physics of Semiconductor Devices. 3rded. John Wiley& Sons.

Glass Science

Course Code: 246PH007

Unit I:
Materials and Classification
Metals, Ceramics and glasses, Polymers, Composites and Semiconductors.

Unit II:
Preparation of Amorphous Materials
Thermal evaporation, Glow discharged composition, Chemical vapour deposition, Melt quenching, gel desiccation.

Unit III:
Glass Transition
Theories of glass transition, thermo dynamic phase transition, entropy, relaxation process, facts that determine the glass transition temperature. Glass forming systems and ease of glass formation. Glass structure and topology, Eutectic composition, Electronic structure.

Unit IV:
Defects in Glasses
Coordination defects (both positive and negative). Atomic vacancies. Density defects, Line defects. D.C. Hopping conductivity, frequency dependent conductivity. Drift mobility.

Unit V:
Applications of Amorphous Materials:
Electronic applications, electrochemical applications, optical applications and Magnetic applications.

Text Books:
1. Elliott,S.R.,1990.PhysicsofAmorphousMaterials.LongmanScientificandTechnical Company, Essen.
2. Shackelford, J.F., 1985. Introduction to Materials Science for Engineers. Macmillan Co., NewYork.

Reference Books:
1. J.E.Shelby.,2005.IntroductiontoGlass Science and Technology. Royal Society of Chemistry.

Industrial Nano-technology

Course Code: 246PH008

UNIT-I:
Nanotechnology in Electrical and Electronics Industry
Advantages of nano electrical and electronic devices–Electronic circuit chips–Nanosensors and actuators, Optical switches– Diodes and Nano-wire transistors -Memory storage – Lighting and displays – Filters (IR blocking) – Quantum computers –Energy devices– Medicaldiagnosis–Conductiveadditives-Lead-freesolder–Nanocoatings –EMI shielding.

UNIT-II:
Nanotechnology in Textiles and Cosmetics
Textiles: Nanofibreproduction-Electrospinning–Controllingmorphologiesofnanofibers– Nano-fillers embedded polypropylene fibers – Bionics – Swim-suits with shark-skin effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes)–Modern textiles (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof clothes), Nano-polymers in medical textiles. Cosmetics: Formulation of Gels, Shampoos, Hair-conditioners (Micellar self- assembly and its manipulation) – Sun-screen dispersions for UV protection using titanium oxide –Colour cosmetics.

UNIT-III:
Nanotechnology in Defense
Military applications of Nanotechnology-Artificial intelligence materials-Propulsion– Vehicles-Propellants and Explosives–Camouflage distributed sensors-Amour protection-Conventional weapons-Soldier systems-Implanted systems, Body manipulation-Autonomous systems - Mini-/Micro robots - Bio-technical hybrids – Small satellites and Space launchers – Nuclear weapons -Chemical weapons–Biological weapons-Chemical/Biological protection.

UNIT-IV:
Nanotechnology in Agriculture and Food Technology
NanoTechnology in Agriculture-Precision farming, Smart delivery system–Nano fertilizers: Nano urea and mixed fertilizers, Nano fertigation – Nano pesticides, Nano – seed Science. Nano technology in Food industry–Nano packaging for enhanced shelf life-Smart/Intelligent packaging-Food processing and food safety and bio-security–Electrochemical sensors for food analysis and contaminant detection.

UNIT-V:
Nano-technology in Environmental and Health Effects
Environmental pollutants in air, water, soil, hazardous and toxic wastes - Application of Nanotechnology in remediation of pollution in Industrial and waste water treatment – Drinking water and Air/Gas purifications-The challenge to occupational health

and hygiene, toxicity of nanoparticles, effects of inhaled nanosized particles, skin exposure to nano- particles, impact of CNTs on respiratory systems, hazards and risks of exposure to nano- particles, monitoring nano-particles in work place and sensors.

Text Books:

1. Brown,P.and Stevens,K.(2006)Nano-fibers and Nanotechnology in Textiles. London:
2. Wood head Publishing. Altmann,J.(2006)Military Nanotechnology: Potential Applications and Preventive Arms Control. Abingdon:
3. Routledge Kuzma,J.and VerHage,P.(2006)Nanotechnology in Agriculture and Food Production. Washington, D.C.: Woodrow Wilson International Center.

Reference Books:

1. Mai,Y.-W.,2006.PolymerNano-composites.WoodheadPublishing.
2. Brinker, U.H. and Mieusset, J.-L. (eds.), 2010. Molecular Encapsulation: Organic Reactions in Constrained Systems. Wiley Publishers.
3. Ajayan, P.M.,Schadler,L.S.andBraun,P.V.,2004. Nano-composites Science and Technology. Wiley-VCH.

Surface Engineering for Nanotechnology

Course Code: 246PH009

UNIT-I:
Introduction to Surfaces
Surfaces and Interfaces– Importance of Surfaces in Nano Regime–Thermodynamics of surfaces– surface energy – notation of surface structures – surface reconstruction –Surface and interfacial tension and measurement–contact angle and wetting–surfactants, and interfacial forces.

UNIT-II:
Processes at Solid Surfaces
Adsorption – Physisorption and Chemisorption – Adsorption isotherms (Langmuir and BET)– Reaction Mechanism (Langmuir-Hinshelwood and Eley-Rideal)–Sticking Probability– Types of Catalyst–Homo vs Hetero-Morphology in Catalysis– Active sites in catalysis &determination–porous materials and supported catalyst–spill over and reverse spillover– Sensor.

UNIT-III:
Role of Surfaces in Bio-Nano-interactions
Adhesion and its importance–Adhesion vs cohesion–Work in adhesion and cohesion
- Methods of adhesion measurement–Adhesion measurement in cell- Surface modification and adhesion - Adhesion of nano-particles, cells and between nano-particle& cells- Cancer cell surface interaction.

UNIT-IV:
Tribological Aspects of Surfaces
Tribological aspects of adhesion, friction and wear– Friction and Friction Types–Theories of Macro (Amontons, Coulomb) and Nano-scale friction (Tomlinson, Frenkel - Kontorova, Bowden and Tabor models)– Difference between macro and micro/nanotribology-Wear– Wear Mechanisms and types–identification of different mechanisms

UNIT-V:
Surfaces in Multidisciplinary Applications
Colloids– Optical and Electrical properties – Colloids in Drug Delivery – Electrical and Electronic properties of Surfaces –zeta potential - Corrosion – Coatings for corrosion protection –High temperature issues - New coating concepts in multilayer structures –thermal barrier coatings.

Text Books:
1. Somorjai,G.A.andLi,Y.,2010.Introduction to Surface Chemistry and Catalysis. John Wiley &Sons, NewJersey.
2. Ibach,H.,2006.Physics of Surfaces and Interfaces. Springer-Verlag, Berlin.
3. Vadgama,P.(ed.),2005. Surfaces and Interfaces for Biomaterials. 1sted. CRC Press, Boca Raton.

Reference Books:
1. Chorkendorff,I.and Niemantsverdict,J.W.,2003.ConceptsofModernCatalysisand Kinetics. 1st ed. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim.

2. Astruc, D. (ed.), 2008. Nanoparticles and Catalysis. Wiley-VCH Verlag GmbH & Co. KGaA,Weinheim.

Advanced Equilibrium and Non-equilibrium Statistical Mechanics

Course Code: 246PH010

Unit I:
Statistical Physics of Liquids
Thermodynamic functions, The classical N-Particle system, Kinetic equations, Time average, Ensemble average, Canonical ensemble, The Boltzmann equation, Static structure factor, Linear response theorem, Brownian motion

Unit II:
Microscopic Dynamics of Liquids and Solids
Computer Simulation of ensembles, Molecular Dynamics, Newton-Raphson method, Runge-Kutta method, Euler method

Unit III:
Nonlinear Fluctuating Hydrodynamics
Nonlinear Langevin equation, coupling of collective modes, Compressible liquid, The nonlinear diffusion equation, Stochastic balance equation, Course grained free energy, Fokker Planck equation

Unit IV:
Non-Equilibrium Dynamics
The non-equilibrium state, generalized fluctuation-dissipation theorem, Computer simulation studies, Effective temperature, the mean field model, FDP regime, Aging regime, Quasi-ergodic behavior

Unit V:
Disordered Solids
The entropy crisis, Metastable structures, Random first-order transition, Self-generated disorder, Effective potential, Overlap functions, Spontaneous breaking of ergodicity, The amorphous solid - the Mezard Parisi model

Text Books:

1. Zwanzig,R.,2001.NonequilibriumStatisticalMechanics.OxfordUniversityPress,UK.
2. Das,S.P.,2011.StatisticalPhysicsofLiquidsatFreezingandBeyond.CambridgeUniversity Press, UK.
3. Chaikin, P.M. and Lubensky, T.B., 1995. Principles of Condensed Matter Physics. CambridgeUniversity Press, UK.

Reference Books:

1. CarolyneMVanVliet,2008.EquilibriumandNon-EquilibriumStatisticalMechanics, world scientific publishing.

Fundamentals of Spectroscopy

Course Code: 246PH011

Unit- I

Interaction between light and matter- Different forms of spectroscopy- Rotational spectroscopy: principles and applications.

Unit -II

Rotational energy levels and transitions- Rotational spectra of diatomic and polyatomic molecules- Analysis of rotational spectra

Unit- III

Vibrational energy levels and transitions- Vibrational spectra of diatomic and polyatomic molecules- Analysis of vibrational spectrum.

Unit- IV

Principles of Raman spectroscopy- Raman spectra of molecules- Applications of Raman spectroscopy.

Unit -V

Electronic energy levels and transitions- Electronic spectra of atoms and molecules- Analysis of electronic spectra, Combination of different spectroscopic methods to solve complex problems.

Books for References

1.Introduction to Molecular Spectroscopy by Gordon M Barrow, McGraw-Hill Inc. US
2.Molecular Spectroscopy by Ira N Levine, Wiley
4.Fundamentals of Molecular Spectroscopy, Colin N. Banwell & Elaine M. McCash, McGraw Hill Education
3.Modern Spectroscopy by J. Michael Hollas, Wiley-Blackwell
5.Fundamentals of Molecular Spectroscopy, P S Sindhu, New Age International Publishers.

Atomic and Molecular Physics

Course code: 246PH012

Unit -I:

Introduction to Atom

Experimental observations and theoretical development in the discovery of constituents of an atom- Structure of an atom with Thomson model, Rutherford model, and Bohr model- Limitations of the Bohr model.

Unit -II:

Atomic Structure

Atomic structure of an atom with magnetic quantum number- Bohr magnetic moment, LS coupling, total angular momentum, and g-factor- Spin-orbit interaction and fine structure.

Unit- III:

Atomic Spectra and Multielectron Atoms

Quantum mechanical treatment of hydrogen-like atoms- Energy levels and wave functions of hydrogen-like atoms- atomic spectra and selection rules.

Unit -IV:

Hydrogen-like Atom in Magnetic Field and Molecular Physics

Hydrogen-like atom in a magnetic field: Zeeman effect and Paschen-Back effect- Physics and rotation of molecules: rotational energy levels and spectra- Vibration of a molecule: vibrational energy levels and spectra.

Unit -V:

Electronic Spectra of a Molecule and Spectroscopy

Electronic spectra of a molecule: electronic energy levels and transitions - Atomic and molecular spectroscopy: principles and applications- Raman spectroscopy and resonance spectroscopy: principles and applications.

Books for References

1. Atomic and Molecular Physics by B. H. Bransden and C. J. Joachain
2. The Physics of Atoms and Molecules by B. H. Bransden and C. J. Joachain
3. Atomic Physics by Max Born
4. Molecular Spectroscopy by Ira N. Levine
5. Raman Spectroscopy by J. R. Ferraro and K. Nakamoto

ELEMENTS OF MODERN PHYSICS

Course Code: 246PH013

Unit –I

Reviews of Classical Physics, Lagrangian Formalism, Special Theory of Relativity, Length Contraction, Time Dilation, Lorentz Transformation, Mass Energy Equivalence, Structure of an Atom, Bohr quantization, Angular momentum, Rurtherford Scattering, Correspondence Principle, Spectral lines, Blamer, Lyman, Bracket, Pfund series,

Unit –II

Stern Gerlach Experiment, Planck's Radiation law, Wave-particle duality, de Broglie relation, Photoelectric and Compton Effects, Probabilistic interpretation, Uncertainty Principle, Phase and Group velocities. Postulates of Quantum Mechanics, superposition principle, Dirac's bra-ket notation.,

Unit-III

Solution of Schroedinger equation in one dimensional problem, Particle in a box, Barrier transmission problems, Harmonic Oscillator, Bound states Solution of Schroedinger equation in 3D. Hydrogen atom, degeneracies, Elementary ideas of Perturbation theory, splitting of energy levels, Stark and Zeeman effects.

Unit-III

Time dependent perturbation theory, Einstein's A, B coefficients, Stimulated Emission and Absorption, Electron spin, spin-orbit coupling, Total Angular Momentum, LS, JJ Coupling, Clebsch-Gordon coefficients. Basics of electromagnetism, Electric and Magnetic Fields, Poynting Vector, Maxwell's equations, Propagation of electromagnetic waves in vacuum and medium

Unit-V

Statistical description of matter, Elementary idea about ensembles, Microcanical, Canonical and Grand canonical ensembles, Liouville's Theorem, Maxwell-Boltzmann (MB), Bose-Einstein (BE) and Fermi-Dirac (FD) distributions,

Applications of Bose Einstein and Fermi-Dirac statistics, Bose-Einstein Condensation (BEC), properties of free Fermi Gas, Pauli paramagnetism. Solid State Physics, Lattice vibration, Specific heat of solids, Semiconductors, p and n type semiconductors, elementary ideas of Magnetism and Superconductivity Week 11: Elementary Nuclear Physics, Binding

Books for References

1. Griffiths, D. J. (1995). Introduction to Quantum Mechanics. Prentice Hall.
2. Resnick, R., & Halliday, D. (1966). Physics. John Wiley & Sons.
3. Pathria, R. K., & Beale, P. D. (2011). Statistical Mechanics. Academic Press.
4. Kittel, C. (2005). Introduction to Solid State Physics. John Wiley & Sons.
5. Krane, K. S. (1988). Introductory Nuclear Physics. John Wiley & Sons.

ELECTRONIC THEORY OF SOLIDS

Course Code: 246PH014

Unit –I

Free electron theory of metals, Fermi-Dirac distribution, Free electrons, boundary conditions, Density of levels in 1, 2 & 3 dimensions, Fermi momentum and Fermi energy, Connection between electron density and Fermi energy. Independent electron systems, degenerate fermi gas: Specific heat, semiclassical theory of transport, Drude theory and Hall effect. Electronic properties of solids: the two-atom solid, theory of electrons in an N-atom solid, linear combination of atomic orbitals – band formation. Periodic potential, Bloch's theorem, tight binding approximation. Brillouin zones for square, triangular, cubic lattices and energy bands in reduced zone scheme.

Unit –II

Fermi surface in several cases, instabilities of the Fermi surface. Novel electronic structures: graphene and carbon nanotubes. Concept of symmetries and their relevance in emergent electronic properties, topological insulators. Elementary concepts of low dimensional electron gas, quantum dot, 1D and 2D electron gas introduced. 2D electrons in a magnetic field, integer quantum hall effect. Spin filtering and magnetoresistance. Spintronics and its applications. Future directions in spin- or valley-tronics.

Unit-III

Magnetism and its origin, magnetization and susceptibility, dia-, para- and ferro-magnetism. Larmour diamagnetism. Hund's rule and paramagnetism, Van Vleck paramagnetism, Curie's law. Thermal properties of magnetic insulators, Pauli paramagnetism. Magnetic interactions, two-electron system, spin-spin interactions – exchange interaction, direct, super and itinerant exchange.

Unit-IV

Magnetic order, Ising, XY and Heisenberg spin models, mean-field theory, ground states and thermodynamics. Phenomenology of Superconductors, Superconductivity in metals and alloys, New Superconductors, Zero Resistance, Meissner Effect, London equation and two- fluid model. Attractive interaction, Cooper problem – instability of the Fermi surface, pair formation and binding energy.

Unit-V

BCS theory, tunneling, SC gap and transition temperature. Sp. heat jump at Tc, coherence length and penetration depth: electrodynamics of superconductors, Type-I and II SC, vortices. Quantum interference, Josephson effect, SC junctions, squid and its application. Novel superconductors.

Books for References

1. Kittel, C. (2005). Introduction to Solid State Physics. John Wiley & Sons.
2. Griffiths, D. J. (1995). Introduction to Quantum Mechanics. Prentice Hall.
3. Kittel, C. (2005). Introduction to Solid State Physics. John Wiley & Sons. (Chapters on magnetism and superconductivity).
4. Dresselhaus, M. S., Dresselhaus, G., & Eklund, P. C. (1996). Science of Fullerenes and Carbon Nanotubes. Academic Press.

Characterization of Polymers, Elastomers and Composite

Course Code: 246PH015

UNIT -I

Introduction of structure-property-process correlation of polymer, elastomer and composites -1. Introduction of structure-property-process correlation of polymer, elastomer and composites -2. Identification by chemical techniques with reference to Indian or International standards.

UNIT -II

Introduction of UV-Vis and Infrared spectroscopy for polymers, elastomer and composites. Application of infrared spectroscopy for blends, modification of polymers, compatibilization, coupling, etc. Introduction to Photoacoustic spectroscopy (PAS), Raman spectroscopy, Atomic absorption spectroscopy.

UNIT - III

Introduction to Electron spin resonance (ESR) spectroscopy, NMR spectroscopy — principles and fundamentals. Application of NMR in polymer, elastomer and composites. Thermal analysis techniques and applications in polymer, elastomer, and composites.

UNIT - IV

Introduction to XRD, XPS, and XRF- Principles, Fundamentals and Application in Polymer, Elastomer and Composites.

UNIT - V

Introduction to microscopy (Optical, AFM) with special reference to electron microscopy (SEM, FESEM, and HRTEM). Application of microscopy in polymer, elastomer and composites. Chromatography, DETA, Quantification from Rate Dependent Methods, Reverse Engineering and Recent Advances.

Books for References

1. Organic Spectroscopy: William Kemp: 3'd Edition: Palgrave USA
2. Spectroscopy of Rubbers and Rubbery materials: Rapra: V. M. Litvinov, P. P. De
3. Characterization Analysis of Polymers: WILEY
4. Scanning Electron Microscopy and X-Ray Microanalysis: Joseph I. Goldstein, Dale E. Newbury, Joseph R. Michael, Nicholas W.M. Ritchie, John Henry J. Scott, David C. Joy, 4th Edition, Springer
5. Electron Microscopy of Polymers: Springer: GH Michler
6. Transmission Electron Microscopy: A Textbook for Materials Science: David B. Williams, C. Barry Carter, Springer
7. Polymer Surface Modification and Characterization: Chi-Ming-Chan: WILEY
8. Elements of X-ray diffraction: B.D. Cullity, Pearson Education 2014.

Properties of Glass Materials

Course Code: 246PH016

Unit-I: Structure of Glasses

Fundamental law of structural models. Elements of structural models for glasses: Coordination of the network cations, network connectivity, dimensionality, intermediate range order, morphology, interstitial / free volume. Structural models for silicate glasses: Vitreous Silica, alkali silicate glasses, alakali/alkaline earth silicate glasses, alakali/alkaline earth alumino silicate glasses rare earth alumino/gallio silicate glasses.

Unit-II: Structural Models for Borate Glasses

Vitreous boric oxide, alkali borate glasses, alkali alumino borate glasses, alakli borosilicate glasses.

Structural models for germanate glasses: Vitreous germania, alkali germinate glasses, fluro germanate glasses. Structural models for phosphate glasses - Halide Glasses - Chalcogenide Glasses - Organic Glasses.

Unit III: Transport Properties

Fundamentals of diffusion, ionic diffusion, ionic conductivity. mechanical Properties: Elastic modulus – Hardnes Fracture strength: Theoretical strength of glasses, practical strength of glasses, flaw sources and removal, strengthening of glass, statistical nature of fracture of glass. Fatigue of glasses – Thermal shock – Annealing of thermal stresses.

Unit IV: Optical Properties

Bulk optical properties: Refractive index, molar& ionic refractivity, dispersion. Ultraviolet absorption – Visible absorption: ligand field coordination glasses, amber glass, colloidal metal colors, colloidal semi-conductor colors, radiation induced colors - Infrared absorption: Infrared absorption by bound hydrogen spieces, Infrared absorption by dissolved gases, infrared cutoffs / multi phonon edge. Other optical properties of glasses.

Text Books:

1. Introduction to Glass Science & Technology (Second Edition) by J.E.Shelby ; Publishers : RS.C
2. S.R.Elliot – Physics of amorphous materials. Longman Scientific and technical company, Essen. 1990)
3. Introduction to Materials Science for Engineers by James F. Shackelford (Macmillan Co.,Newyork. 1985)